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Assessment of Evidence for the Presence in Victoria of a Wild Population of 'Big Cats '

P. W. Menkhorst and L. Morison

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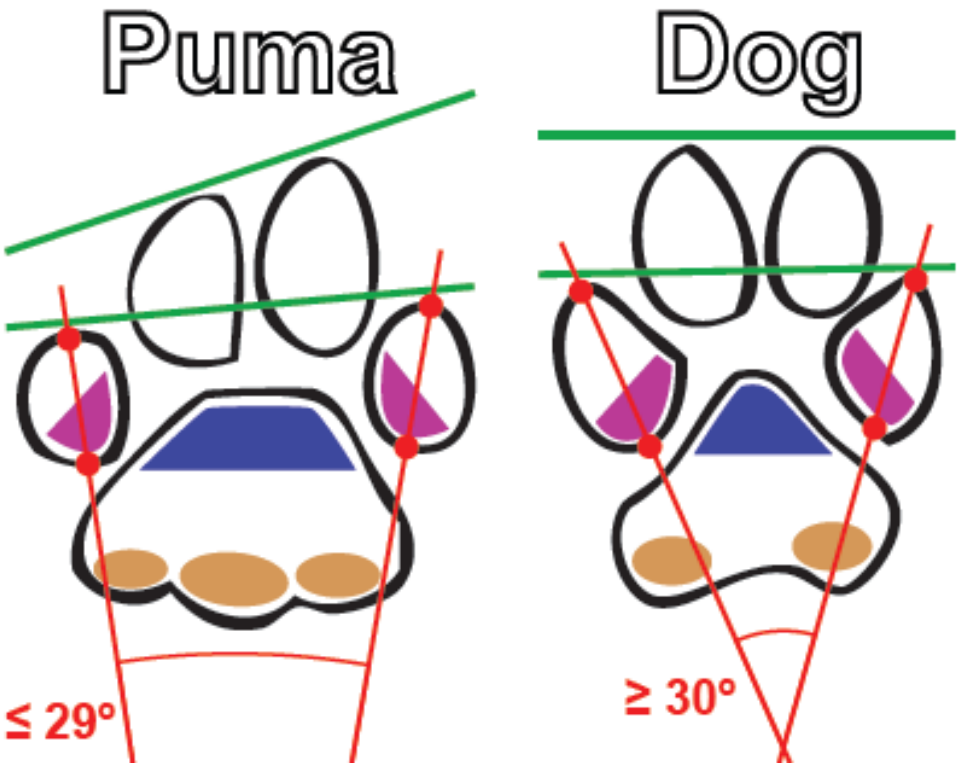

Arthur Rylah Institute for environmental research

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Front cover photo: Diagram indicating differences between the tracks of Puma *(Felis concolor)* and Dog (*Canis lupus*): an example of the complexities involved in the interpretation of 'signs' of the existence of unidentified, large, carnivorous mammals. Source: Puma Identification Guide. www.cougarnet.org

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Summary

A review of information pertaining to the possible presence in Victoria of a wild population of unknown species of 'big cat(s)' was undertaken. There are no records of 'big cats' in official zoological databases managed by Victorian Government agencies, despite considerable fauna survey, research and monitoring in the State over many decades. However, there are many thousands of reports of 'big cats' in the files of community cryptozoological groups and individuals.

We classified the types of evidence that have been used to support claims of the existence of 'big cats' in Victoria into three broad classes based on the veracity of the evidence they provide. Most reports involve sightings of an animal or signs of the presence of a large, unknown animal and are inconclusive without further physical corroborating evidence. The clear conviction of some observers about what they saw does not materially increase the veracity of the identification. Other reports involve the finding of dead and partially eaten livestock or wildlife where the volume of flesh removed and manner in which the flesh is removed are claimed to be beyond the capabilities of known predators in Victoria. There are two possible explanations for such cases – that an unknown predator is responsible, or that our understanding of the behavioural repertoire of known predators is inadequate. The latter explanation seems most prudent at this stage.

The most parsimonious explanation for many of the reported sightings is that they involve large, feral individuals of the Domestic Cat *Felis catus*. However, some evidence cannot be dismissed entirely, including preliminary DNA evidence, footprints and some behaviours that seem to be outside the known behavioural repertoire of known predators in Victoria.

Obtaining unequivocal evidence for the presence of 'big cats' in Victoria would require an organised and structured program aimed at collecting DNA samples from faecal material or prey carcasses, or the opportunistic collection of a number of 'big cat' carcasses of proven provenance. Any such specimens need to be presented to Museum Victoria for incorporation into the State's mammal specimen collection so that they can be properly curated and are available to researchers in future. [Note that more than one specimen would be required because the presence of a single individual is not evidence of a self-sustaining population].

1 Introduction

In response to persistent reports and rumours of the existence of large cat-like animals in the wild in Victoria, the Minister for Agriculture and Food Security requested, in May 2012, a science-based, preliminary assessment of the available evidence. Big cats are apex predators and a wild population, were it to exist, could have economic implications for some farm businesses, could adversely affect fauna conservation programmes, and the possibility of risk to public safety could not be dismissed (although there have been no suggestions of attacks on humans by 'big cats' in Victoria).

This report presents the results of a short review of the veracity of the types of evidence held by State Government departments and by interested members of the public. It also recommends a research approach that is most likely to provide an answer to the identity of predators responsible for killing livestock, should further investigation be decided upon.

1.1 The Issue

No species of cat (family Felidae) is native to Australia and only one species, the Domestic Cat *Felis catus*, is recognised as having established a wild, self-sustaining population in Australia. Accordingly *Felis catus* is the only cat included in lists of the Victorian (Menkhorst 1983; Menkhorst 1995) and Australian (Walton 1988; Van Dyck and Strahan 2008; Menkhorst and Knight 2011) mammalian fauna, and it is listed as an introduced or alien species.

In seeming contradiction to the official stance are reports of sightings of large cat-like animals from Victoria that have been made since the late nineteenth century and span the entire State except for the semi-arid north-west. Anecdotal reports of sightings or signs of large predatory mammals now total in the thousands. Unsurprisingly, the quality of information associated with these records varies greatly between reports, but some reports involve close observation and careful documentation by credible observers. Another line of evidence relates to the killing and consumption of livestock (sheep, cattle, horses) that is thought to fall outside the capabilities of known predators or scavengers (Dog *Canis lupus*, Pig *Sus scrofa*, Red Fox *Vulpes vulpes*, Domestic Cat *Felis catus*, Lace Monitor *Varanus varius* and predatory birds), or where the forensic condition of the carcass suggests that the killing and consumption were not the work of known predators (Figure 1).

Similar sightings and predation events are reported from other Australian States and from other countries including Britain (see for example http://en.wikipedia.org/wiki/Beast_of_Bodmin; http://en.wikipedia.org/wiki/Beast_of_Exmoor), Ireland, New Zealand, Finland, Denmark and the United States of America. The wide geographic spread and temporal span of claims of alien 'big cats' and other predators suggests that it may be a human sociological phenomenon, rather than a biological fact. Consequently, claims of the presence of alien big cats, which are rarely, if ever, supported by convincing evidence, are seldom taken seriously by mainstream zoologists.

In Victoria, several interested individuals or groups have assiduously compiled databases of anecdotal evidence (for example Henry 2001; Costello 2003; http://www.bigcatsvic.com.au/; http://www.arfra.org). Continuing media interest in reported sightings, and the existence of unexplained predation on livestock and macropods (Townsend 2011), has resulted in widespread acceptance, especially in rural communities, that such creatures exist. Indeed, belief in the existence of 'big cats' or 'panthers' in Victoria has taken on some characteristics of folklore (Henry 2001; D. Waldron, University of Ballarat pers. com.). This belief persists despite the lack of scientifically supported, physical evidence of unquestioned provenance (see below).

Figure 1. Example of consumption of livestock that raises questions about the identity of the perpetrator. The hindquarters and abdominal cavity of this still-born calf are said to have been totally consumed overnight by an animal with neat and thorough feeding habits, unlike those of a pack of dogs or wild pigs.

It is acknowledged that individuals of a number of species of 'big cat' could have escaped from captivity and lived for a period as wild animals at some time since the 1850s. Indeed, at least one Lion is known to have escaped from an open-range zoo near Bacchus Marsh during the 1980s and it roamed free in the local area for some time before being recaptured. Such individual animals are not the focus of this report, rather, the question is whether or not there could be a self-sustaining population of 'big cats' in Victoria.

1.2 Project Aims

The project had two aims:

1. To make an informed assessment of the types of evidence that support the presence of a wild population of a large, unknown species of cat (Family Felidae) in Victoria.
2. To recommend the most efficacious investigations that would further define and quantify the magnitude of this issue for the Victorian Government.

2 Methods

2.1 Accessing Information

Information pertaining to claims of unknown species of large mammals occurring in Victoria is held by a range of entities including cryptozoological[1] community groups, private individuals and Victorian Government agencies. Because of the short time available for this study it was impractical to attempt a comprehensive assessment of all available material. Instead, we attempted to quickly familiarise ourselves with the issue by seeking information from the following sources:

1. Files compiled by Victorian Government agencies – Department of Sustainability and Environment (DSE) (files 85/3042 parts 1-4 and FF/53/0014), Department of Primary Industries (DPI) (material which had previously been made available to others under Freedom of Information legislation was provided in June 2012), Zoos Victoria, Parks Victoria and Museum Victoria. We also accessed reports from the New South Wales Department of Primary Industries into unidentified animal sightings in that State (Bauer 1999; NSWDPI 2003; 2008; 2009).
2. Material collated by community-based 'big cat' investigators that is publicly available in the literature or online (e.g. Australian Big Cats http://www.australianbigcats.com/, Big Cats Victoria: Sightings, Photos, Physical Evidence http://bigcatsvic.com.au/, Home - Australian Rare Fauna Research Association http://www.arfra.org/ , Big Cats Entry Page http://www.paulclacher.com.au/bigcatsentry.htm, Australia's new feral mega-cats – Tetrapod Zoology http://scienceblogs.com/tetrapodzoology/2007/03/04/australias-new-feral-mega-cats/).
3. Evidence provided on request by cryptozoologists and community groups.

2.2 Identifying candidate species

We used checklists of Victorian and Australian mammals (Walton 1988, Menkhorst 1995, Van Dyck and Strachan 2008, Menkhorst and Knight 2011) and discussions with colleagues to develop a list of species of large predatory mammals that are known to occur in the wild in Victoria, or which could conceivably be the source of claims of 'big cat' presence. For these species we collated details of diagnostic identification features, morphometrics, and characteristic signs and behaviours, including faecal material (hereafter called scats), tracks, hunting and killing strategies and feeding behaviours (Appendix 1).

We collated material on post-mortem identification of animals responsible for killing livestock, including that used in North America (MacKay 2005; Shaw *et al.* 2007; Internet Center for Wildlife Damage Management 2012; Texas Natural Resources Server 2012) and by fox and wild dog researchers and controllers in Australia (Saunders *et al.* 1995; Fleming *et al*. 2001; Saunders and McLeod 2007; Greg Ivone, DPI *pers. com.*).

We also investigated the practicality of attempting to identify predators via DNA left on carcasses, for example in saliva (see for example Blejwas *et al*. 2006), by DNA extracted from scats (see for example Berry *et. al*. 2007) and by forensic veterinary examination of carcasses (see for example Coard 2007).

2.3 Assessing the Available Evidence

After considering the range of evidence available we recognised three hierarchical classes of evidence which we have labelled primary, secondary and tertiary:

[1] **Cryptozoology** (from Greek κρυπτός, *kryptos*, "hidden" + zoology; literally, "study of hidden animals") refers to the search for animals whose existence has not been proven.

- Primary evidence consists of a physical specimen of a body (alive or dead), or diagnostic part thereof. Diagnostic body parts can include bones, teeth, feet, fur and DNA.
- Secondary evidence has two categories:
    - a) a sighting that includes photographic or video images of the animal or a recording of vocalisations
    - b) a sighting or report of vocalisations without further evidence

  If the images are of adequate quality, type 2a evidence would carry more weight than type 2b evidence. High quality images with unambiguous corroborating evidence about the provenance of the images would approach primary evidence in level of veracity.
- Tertiary evidence is sign that an animal has been present – footprints, scats, scratch marks, carcasses of prey animals killed by a predator. Scats and prey carcasses can potentially yield primary evidence in the form of hairs or DNA.

Table 1. Summary of the types of evidence that fall into each evidence class.

Evidence class	Type of evidence
Primary	specimen of the animal, skeletal material, teeth, fur, DNA
Secondary	a) sighting supported by photographs, video or aural recording
	b) sighting or sounds heard
Tertiary	footprint, scat, prey carcass, scratchings etc

Note that in the case of species that have not been officially recorded in a given area, a higher level of certainty is required before a reported occurrence can be accepted – because the presence of such species is not supported by primary evidence such as museum specimens. Isolated cases involving only secondary or tertiary evidence cannot constitute unequivocal evidence. Rather, they provide hints about the possible identity of the animal concerned. Whilst many people have strongly-held views about sightings made by themselves or their acquaintances, such single, isolated sightings cannot be verified.

3 Results

3.1 Information available

Reports of 'big cats' in Victoria number in the thousands and span over 100 years. Despite this, there has been no comprehensive and coordinated attempt by any Victorian Government agency to collate and curate this information so that a fully informed assessment can be made. DSE and DPI have maintained files of material but the effort has been inconsistent and intermittent. Recently, a considerable body of material has been made publicly available in the Australian Animal Folklore Collection, Geoffrey Blainey Research Centre, University of Ballarat.

Several community-based cryptozoological groups and individuals have assiduously collated reports of unidentified mammals and have developed large databases of records of secondary and tertiary evidence. This evidence includes photographs of animals and casts of footprints but in most cases the quality of these artefacts is poor and the results are inconclusive. Further, these databases of evidence have not been subjected to independent and scientifically rigorous assessment. Without such assessment, these private databases have limited capacity to advance understanding of the issue. Where rigorous assessments have been conducted the conclusion has always been either inconclusive, or that the most parsimonious explanation involves a known species, notably Domestic Cat or Dog. One native species, the Black Wallaby (*Wallabia bicolor*) may also explain some sightings – it has a long, blackish, cylindrical tail which is often held in a gentle curve when the animal is moving. It is possible that some sightings involving only the hindquarters of a fleeing animal are attributable to the Black Wallaby, a common and widespread species in Victoria.

A small number of the cases we reviewed either showed characteristics considered unusual in known species or showed characteristics known to occur in large felids, such as dragging and covering a carcass, or peeling back the skin from a limb of a carcass to access the flesh, a feat requiring considerable strength. Assessing this evidence either requires us to expand the pattern of behaviours attributable to known species of predator (for example, Dog), or deduce the presence of an unknown species. In the absence of convincing corroborating evidence for an unknown species, the former conclusion is considered the most appropriate at this stage. In other cases people have claimed that known predators, such as wild Dogs or Pigs, are not present in a district, and therefore predation must be caused by an unknown species (i.e. 'big cat'). It seems more likely that our understanding of the distributions of known predators is inadequate.

One intensive study conducted by staff and students from Deakin University during 1976 and 1977 concentrated on The Grampians region in western Victoria (Henry 2001). This study adopted an objective, science-based approach by the prior development of a rigorous logic and tests to be applied to each category of evidence. It produced some interesting tertiary evidence and historical information pertinent to the widely-cited theory that Pumas were kept as mascots by members of USA military forces based in the region during the early 1940s and released into The Grampians prior to their departure. Our interpretation of the evidence for the military mascot hypothesis presented by Henry (2001) is that it is equivocal at best – all the USA servicemen who responded to requests for information stated that they were not aware of any animals being brought to Australia as mascots. Note also that the mascot hypothesis applies only to the Puma during the period after the Second World War. It cannot explain reports pre-dating that time, nor can it explain reports of animals more closely resembling the Leopard. Other aspects of the Deakin Puma Study are discussed under Section 3.3.1 below.

In stark apposition to the records collected by community-based groups are the results of formal surveys of Victoria's mammalian fauna which have detected no evidence of any large predatory mammals in Victoria apart from wild Dogs and Pigs. Government fauna surveys began in the 1850s with the creation of the Natural History Museum in Melbourne and the appointment of Wilhelm Blandowski as its first zoologist (Menkhorst 2009). Fauna surveys have continued to the

present day and during the 1970s and 1980s investigated almost all Crown Land in the State as part of the Land Conservation Council of Victoria's review of the values of the State's Crown Land (Clode 2006). The results of the mammalian component of this work are summarised in Menkhorst (1995) and are collated in databases maintained by Museum Victoria (specimen catalogue with approximately 24 000 mammal specimens collected in Victoria) and by DSE (Victoria's Biodiversity Atlas which contains details of more than 160 000 mammal records from Victoria).

3.2 If 'big cats' exist in Victoria what species could they be?

If one assumes that there are wild 'big cats' in Victoria, the reported morphological characteristics and behaviours suggest that any such animals are most likely to be a mid-sized species, i.e. not Lion or Tiger or any of the 28 species of 'small' cat recognised globally (Johnson *et al*. 2009; Sundquist and Sundquist 2009). The most likely candidates are the Leopard (*Panthera pardus*) of Africa and Asia (Figure 3), and the Puma (*Felis concolor*) of the Americas (also known as Cougar and Mountain Lion), though the Jaguar (*Panthera onca*) of Central and South America cannot be ruled out.

Although the name 'panther' is commonly applied to supposed 'big cats' in Victoria, that name does not apply to any species of felid and has no defined scientific meaning. It is sometimes applied to melanistic (black) individuals of the Leopard or Jaguar.

Sightings mostly refer to a long, low-slung, black cat with a squared head, powerful, muscular legs and feet, yellow irides with a dark circular pupil, and a long, cylindrical tail which curls up at the end. This description fits with the Leopard or Jaguar, although the Jaguar is more heavily built, deep-chested and powerful with a proportionately shorter tail. The best fit is with subspecies *delacouri* of the Leopard (Figure 4) which occurs from south China to the Malay Peninsula (and in historical times to Java). It has a gracile build and is frequently black (Kawanishi 2002; Sunquist and Sunquist 2009), with up to 50% of the population said to be melanistic (Stander 2009). Melanism is also said to be common in the Jaguar (Sunquist and Sunquist 2009).

Other reports refer to uniformly pale tawny or fawn-coloured animals with whitish bellies. This colour pattern does not fit with Leopard or Jaguar but it does fit Puma. Other distinguishing features of the Puma include proportionally the longest hind legs in the Family Felidae and pale grey-brown irides (Johnson *et al*. 2009; Sunquist and Sunquist 2009).

Some reports refer to hearing deep, low-pitched, rasping or growling sounds, which fits with Leopard/Jaguar but not well with Puma which makes a range of voclaisations including spits, hisses, purring, whistle-like sounds and a 'screaming' call (Stander 2009). Some cryptozoologists believe that both Leopard and Puma are present in Victoria.

Although feral Domestic Cats can attain a large size (weights of up to 16 kg have been claimed (Denny and Dickman 2010)), all scientific studies indicate that they are mostly small and thin, weighing between 2 and 6 kg (Jones and Coman 1982, Denny and Dickman 2010, M. Johnston ARI pers. com.). The widespread view that feral Domestic Cats frequently attain much larger dimensions than their pet conspecifics has little scientific support – it may be another example of myth-making around cats in Australia. However, the Kurt Engel specimen (discussed under 3.3.3 below) supports other sightings of very large, black, feral Domestic Cats present in high rainfall regions of Victoria and NSW (see discussion of the 'Lithgow panther' case under 3.3.1 below). The evolutionary pressures that would lead to gigantism amongst wild Domestic Cats in some regions are not clear, but may include ready availability of medium-sized prey such as European Rabbit (*Oryctolagus cuniculus*) and sub-adult macropods. The apparent predominance of melanistic individuals amongst this subset of giant animals also remains unexplained.

Even large individuals of the Domestic Cat can be readily distinguished from 'big cats' based on body proportions and conformation (Figures 2 and 3; Appendix 1). Wild Domestic Cats have relatively longer legs and a shorter body length, smaller, less powerful feet, a proportionally

Figure 2. Still from a video recording purporting to show a 'black panther' in central Victoria. Source: Australian Animal Folklore Collection, Geoffrey Blainey Research Centre, University of Ballarat.

This animal can be readily identified as a Domestic Cat *Felis catus* by its pointed ears placed high on the head, proportionally short tail, skinny forelimbs, narrow neck and the shape of its head (*c.f.* Figure 3).

Figure 3. A hunting Leopard in Savuti National Park, Botswana. Photographer P. Menkhorst

Note the thick, square muzzle, rounded ears placed on the side of the head and not projecting far above the skull, thick neck, heavy forelimbs and feet, projecting shoulder blades and long cylindrical tail with short, coarse hair.

shorter tail with longer, softer fur, pointed ears placed higher on the head, and the pupil is elongated vertically, not round (though, in darkness, when fully dilated, the pupil approaches circularity). Further, a wide range of fur colour patterns is present in feral Domestic Cats, including tabby, ginger, tortoiseshell and uniformly black (M. Johnston pers. com.; PM pers. obs.) whereas reports of 'big cats' mostly refer to a uniform colour pattern of black, tawny or greyish fur.

Figure 4. Images from the Malaysian Peninsula of melanistic individuals of the local subspecies of Leopard *Panthera pardus delacouri* .
Note the gracile build, long, short-haired tail, heavy forelimbs and feet, and 'shadow' of leopard spots visible in the pelage of the animal in the lower right image. Source: http://www.nwf.org/News-and-Magazines/National-wildlife/Animals/Archives/2007/Malasian-Mystery.aspx

The three main candidate species (Puma, Leopard and Jaguar) all occupy broad ecological niches in their extensive native ranges (Stander 2009; Sunquist and Sunquist 2009). Jaguars are the most specialised: they are confined to forests in South and Central America, and are strongly associated with watercourses which they use for hunting, and for cooling during the day. Pumas are associated mainly with remote country, from sea level to 4000 m in North, Central and South America: they occupy forested and open rocky habitats and may depend on an abundance of deer-sized prey which they hunt from suitable ambush sites (Currier 1983). Leopards are the most versatile of all, occurring in a vast range of habitats across their range in Africa and southern Asia, from deserts to savannahs and dense forest, and taking a huge range of small and large prey species.

3.3 Veracity of the available evidence

3.3.1 Secondary and Tertiary Evidence

The mass of evidence in the tertiary and secondary classes does not unequivocally answer the question of whether or not a large, unknown mammalian predator exists in the wild in Victoria. Over several decades, a number of dedicated people have attempted to use secondary and tertiary evidence to prove the existence of 'big cats' in Victoria and elsewhere in Australia, with perhaps the best examples being Henry (2001) and the 'Lithgow panther' case in NSW. In the latter case an expert panel comprising representatives of the Australian Museum, Taronga Zoo, NSW

National Parks and Wildlife Service and NSW Agriculture examined video footage and concluded that the animal was a 'very large feral cat, two to three times normal size' (NSW DPI 2009).

One line of evidence that has some potential to advance our understanding is the forensic examination of prey carcasses, both livestock and wildlife. Reliable post-mortem predator identification from a prey carcass requires discovering the carcass while relatively fresh and skinning the carcass to look for puncture wounds, damage to bones, and other signs that could provide information on tooth dimensions and structure, for example (MacKay 2005; Saunders *et al*. 1995; Coard 2007; Internet Center for Wildlife Damage Management 2012; Texas Natural Resources Server 2012). However, even this level of evidence cannot prove the identity of the predator.

The Deakin Puma Study Group

The Deakin University study in The Grampians during 1976 and 1977 (Henry 2001) is particularly interesting because of its scale and the objective, analytical approach that was adopted. However, despite the stated aims of objectivity we have discerned some potential sources of bias in the approaches used. For example, the title given to the study – Deakin Puma Study – is likely to have led to unconscious bias in the volunteer participants, predisposing them to read 'Puma' into inconclusive evidence. For example, one piece of potential primary evidence collected during the study is a large predator scat or regurgitated pellet 80 mm long and 50 mm in diameter referred to as Geranium Springs scat 2. When analysed by Hans Brunner, it was found to contain remains of sheep and fox, but no grooming hairs, so the species that produced it remained unknown (Henry 2001). However, it contained bone material of a size (up to 60 mm long) that is not seen in scats from members of the Canidae (dog family) because their molar teeth are specially designed to crush bones into small, digestible pieces, in contrast to the shearing carnasial teeth of Felidae (cats). Despite advice from Monash University zoologists that the object was a regurgitated pellet, the Deakin Puma Study Group concluded that it was a scat, most probably from a Puma. This scat became one of five pieces of evidence upon which Henry (2001) based his conclusion that there 'is sufficient evidence from a number of intersecting sources to affirm beyond reasonable doubt the presence of a big-cat population in Western Victoria.' However, in an addendum to the report, Henry (2001) admits that the Geranium Springs scat 2 is most likely a regurgitated pellet from a Wedge-tailed Eagle. We believe that this revised finding is indicative of the Deakin Puma Study Group falling into the understandable position of being captured by the legend it was seeking to prove.

Another case worthy of close consideration involves photographs of two clear footprints on a sandy track in Longford Pine Plantation taken in December 2005 and supplied by Richard Sealock, along with an analysis of their size and shape. We agree that these footprints are highly likely to have been made by a cat and that their reported dimensions are greater than could be explained by a Domestic Cat, however, that is as far as that line of evidence can be taken.

We find that none of the investigations that have focussed on secondary and tertiary evidence has succeeded in providing an unequivocal answer. We see little point in dedicating public resources to that line of inquiry.

3.3.2 Primary Evidence

Primary evidence of unquestioned provenance is required to be certain of the existence of 'big cats'. We are not aware of any unequivocal primary evidence for the existence of 'big cats' or other unknown, large, terrestrial, predatory animal in Victoria or elsewhere in Australia. We are, however, aware of three Victorian cases which yielded results that warrant closer examination. These are discussed separately in section 3.3.3 below.

We find that the lack of primary evidence is more convincing than any of the evidence claimed to support the presence of 'big cats'. In particular, we note that:

- No specimen of any unknown, large mammal species has been gathered during extensive wildlife surveys and field research conducted by the Victorian Government, universities and field naturalist groups during the 20th and 21st centuries. The intensity of wildlife research and survey has increased dramatically since the 1960s (Menkhorst 1995, Menkhorst *et al.* 2009), commensurate with an increase in the frequency of reports of 'big cats' and community interest in them. Yet no suggestion of any inexplicable faunal species has been found. The intensity of this fauna survey effort is indicated by discovery of new and highly cryptic mammal species during that period, species that were either new to science (for example Long-footed Potoroo *Potorous longipes*), discovered in Victoria for the first time (for example Mallee Ningaui *Ningaui yvonneae*, Little Pygmy-possum *Cercartetus lepidus*, Heath Mouse *Pseudomys shortridgei*, and several species of bat), or re-discovered after having been thought to be extinct (Leadbeater's Possum *Gymnobelideus leadbeateri,* Mountain Pygmy-possum *Burramys parvus*) (Menkhorst 1995).
- Museum Victoria has approximately 24 000 catalogued mammal specimens collected in Victoria. None of these is from a large, wild felid or other unknown species of carnivore (Wayne Longmore, Mammal Collections Manager *pers. com.*).
- No 'big cat' scats have been identified during studies involving the systematic collection and analysis of thousands of mammalian predator scats (feral Domestic Cat, wild Dog (includes Dingo), Red Fox) undertaken as part of studies of predator diet and as a mammal survey technique (for example, Brunner *et al*. 1976, Klare *et al*. 2011).
- No photographs of large, unknown animals have been captured by the relatively new survey technique of heat-in-motion-triggered cameras. For example, staff of DSE's Arthur Rylah Institute for Environmental Research have examined many tens of thousands of images captured using this technique from cameras set in remote forested country across much of Victoria, including hundreds of images of feral Domestic Cats, wild Dogs/Dingoes and Red Foxes (ARI unpublished data). A pertinent example given the conclusions of the Deakin Puma Study Group, is that a recent study involving about 1840 camera trap-nights targeted at detecting Foxes and Domestic Cats in the Grampians National Park failed to record any unexpected species (A. Robley, ARI unpublished data).
- With expanding introduced populations of four species of deer in Victoria (Menkhorst 1995; Victorian Biodiversity Atlas data) the available prey for 'big cats' is also presumably increasing and expanding (deer being important prey for Leopards and Pumas within their natural range). This, in turn, ought to be producing an expanding population of predators which ought to increase the probability of obtaining primary evidence of their existence. Current research into the impact of deer carcasses left in the bush by hunters on the behaviour of wild Dogs involves the deployment of heat-in-motion-triggered cameras placed at deer carcasses. This has produced many photographs of scavenging mammals and birds, but has not produced any sign of 'big cats' (D. Forsyth ARI pers comm.).
- Conversely, on each occasion when primary evidence has been obtained the identity has been Dog or Cat. For example, the well-publicised 'Tantanoola Tiger' which roamed the far south-east of South Australia in the 1890s was eventually shot and found to be a large, pale dog (said to be an 'Assyrian Wolf'). More recently, the hide of the 'Briagolong Beast' of the 1930s was identified by the Curator of Mammals at Museum Victoria, Charles Brazenor, as belonging to a large, black dog (The Mail, 13 June 1936 page 5), and the Kurt Engel cat was shown to be a Domestic Cat (see under 3.3.3).

3.3.3 Attempts to obtain primary evidence

We are aware of three attempts to obtain DNA evidence of the identity of suspected 'big cats' in Victoria.

The Kurt Engel cat

A large, black cat was shot by Mr Kurt Engel in central Gippsland in June 2005. Photographs of this animal were widely publicised in the media but only its tail was retained as evidence. DSE arranged for the extraction and analysis of DNA from a small sample of skin taken with permission from this tail. The analysis was undertaken at the Department of Genetics, Monash University, and the result was that the sample exhibited between 97.7% and 100% sequence identity with the Domestic Cat, and only 87% sequence identity with the Leopard (Kate Charlton in lit. to Bernard Mace, 24 November 2005, copy on DSE file 85/3043-4). The length of this cat's tail, at 65 cm, is twice that of a normal Cat (Appendix 1) but it may have been stretched during skinning, a common occurrence if care is not taken. Hence, the conclusion is that the animal was a particularly large individual of *Felis catus*, the Domestic Cat.

The Winchelsea faecal sample

In November 1991, a member of the public collected a large scat in the Winchelsea district and provided it to an officer of the Department of Natural Resources and Environment. This specimen was sent to Barbara Triggs, an expert in the analysis of scats and their contents. She described the scat as having a 'particularly strong and unpleasant' odour, 'very similar to the odour of the faeces from the zoo black leopard' [refers to a faecal sample from a melanistic Leopard then held at Melbourne Zoo provided for comparison by Dr Helen McCracken, a Melbourne Zoo veterinarian] and 'stronger and more acrid than that of any wild dog scat I have examined' [and Triggs has examined many hundreds of dog and fox scats].

Triggs was able to extract four black hairs from the Winchelsea scat that she believed belonged to the animal (rather than its prey) and had been ingested inadvertently while it groomed its fur. The structure of these hairs was examined microscopically using the methods of Brunner and Coman (1974), a technique in which Triggs is a national expert. These hairs were compared to hair samples from the Melbourne Zoo black Leopard and a Puma, also supplied by McCracken. Triggs concluded that two of the hairs from the Winchelsea scat had 'very similar features' to the hairs from the zoo Leopard. She concluded that 'there was a possibility that the Winchelsea faeces were from a big cat such as a black leopard. However, there was not enough evidence to make a positive identification' (B. Triggs in undated report to D. Cass held on DSE file FF /53/0014). A second faecal sample from Winchelsea was received by Triggs in December 1991 and more black hairs were extracted and analysed in the same manner. These hairs were sent to a second expert, Mr Hans Brunner, for a second opinion, without providing Brunner with any background information, i.e. a blind trial. Brunner's opinion was that the hairs 'were probably from a Cat, *Felis catus*.' When told that the faeces were very large, had a very strong odour and were most unlikely to be from a feral or domestic cat, he replied that 'a large, panther-like animal could not be excluded'.

The remaining hairs were stored in a sealed plastic bag until August 2000 when they were subjected to molecular analysis by Dr Stephen Frankenberg, Department of Zoology, La Trobe University. Frankenberg found that the region of mitochondrial DNA he tested was 'identical to the corresponding published sequence from *P. pardus* [the Leopard] within the region of overlap, with the exception of one nucleotide at position 109.' Frankenberg concluded that 'the source of the Otway sample [actually from the Winchelsea district, a farming region north of the Otway Ranges] was *P. pardus* and that the single nucleotide difference at position 109 represents a

sequence polymorphism within the species.' (Frankenberg and Cass undated and unpublished draft report now placed on DSE file FF /53/0014).

This result seems not to have been formally conveyed to any Government Department and has not been publicised before this study. Frankenberg has personally conveyed that the decision not to publish was largely because the result could not be considered 100% reliable due to a small possibility of contamination (note that Triggs had leopard hairs in her workshop). Nevertheless, he thought that, when combined with the morphological evidence from the hairs, the result was quite likely to be real, since the PCR assay was designed to detect any species of cat (i.e. was not selective for leopard) and thus any contamination was unlikely to mask the detection of endogenous DNA in the scat sample (which was almost certainly felid from the morphological evidence).

Carrie Magnik BSc Hons thesis

In the late 1990s a high rate of predation of sheep in parts of South Gippsland created widespread interest. Attempts to identify and even to trap the predator did not produce results. Carrie Magnik, an Honours student in the Department of Genetics at La Trobe University conducted a study that attempted to extract predator DNA from saliva samples taken from attacked sheep, and from scats collected in the area (Magnik 2000). Canine- and feline-specific microsatellite markers were used to determine if dog or cat DNA was present in any samples. Two of 12 saliva samples indicated the presence of canine DNA and none indicated the presence of feline DNA so there is no evidence that the livestock were killed by any species of cat. However, the results were considered to be inconclusive because: 1) the tests could not exclude the possibility that farm dogs had access to the carcasses before the samples were collected, and 2) the possibility of contamination between sample collection and processing could not be excluded (Magnik 2000; N. Murray La Trobe University Department of Genetics pers. comm.). Faecal sampling was also inconclusive because of a failure to extract feline DNA, even from control samples.

These three cases highlight the difficulties in extracting and identifying traces of DNA from secondary sources such as carcasses and scats. Even when successful at extracting and amplifying DNA, the results will be probabilistic rather than binary.

4 Discussion

4.1 Veracity of available evidence

No unequivocal evidence supporting the presence of 'big cats' in Victoria was found in this study. Perhaps even more compelling is the lack of evidence. One has to wonder why no 'big cat' has ever been detected in a formal wildlife survey, shot by a hunter or farmer, hit and killed by a vehicle, or why no skeletal remains have been found. These sources have yielded primary evidence of the existence of wild populations of 140 species of mammal in Victoria (Menkhorst 1995), some of which are highly secretive and difficult to observe – why no 'big cats'?

The most parsimonious explanation for many of the reported sightings is that they involve large, feral individuals of the Domestic Cat *Felis catus*, such as the Kurt Engel specimen. Feral Domestic Cats when in good condition can display increased overall muscle development, especially noticeable around the head, neck and shoulders, giving the animal a more robust appearance (Anon. 2003). However, a number of records involve descriptions of animals or footprints by informed observers, such as farmers and hunters, which do not fit the Domestic Cat model and are difficult to explain without resort to a 'big cat' model, including some of those discussed above.

With the rapid advances in genetic screening technology, new avenues of investigation are available which have the potential to provide definitive results. In particular, the extraction, amplification and identification of predator DNA from carcasses and scats could be pursued. This could involve training and equipping existing DSE and DPI staff to take suitable samples from carcasses after being notified of their existence by cooperating landholders. Over a period of time an adequate series of samples could be obtained to allow a definitive statement about the identity of the predators involved.

Only primary evidence in the form of specimens of unquestioned provenance, or DNA from sources of unquestioned provenance, can establish, once and for all, that a population of 'big cats' occurs in Victoria and the specific identity of the animals. High quality photographic images provide the second best level of evidence. Any such specimens, including DNA samples and photographic material, need to be formally registered into the collections of Museum Victoria for long-term storage as scientific specimens.

5 Conclusions

1. The available evidence is inadequate to establish that a wild population of 'big cats' exists in Victoria.
2. The lack of any formal evidence from considerable mammal survey effort, using a broad range of techniques over many decades, strongly suggests that there is no wild population of 'big cats'.
3. The most parsimonious explanation for many of the reported sightings is that they involve large, feral individuals of the Domestic Cat *Felis catus*.
4. Notwithstanding conclusions 1-3, some evidence cannot be dismissed entirely, including preliminary DNA evidence, footprints and some behaviours that seem to be outside the known behavioural repertoire of known predators in Victoria.
5. Only primary evidence in the form of specimens of unquestioned provenance, or DNA from sources of unquestioned provenance, can establish, once and for all, that a population of 'big cats' occurs in Victoria, and the specific identity of any such animals. High quality photographs of proven provenance would also constitute compelling evidence.

6 Recommendations

We recommend that if the 'big cat' issue is considered to warrant further investigation by Government, work should focus on obtaining primary evidence. We suggest the following priorities:

1. Assess the efficacy of using molecular techniques (DNA fingerprinting) to identify species of predatory animals responsible for eating livestock carcasses.
2. Reach agreement with appropriate genetic laboratories to undertake DNA analysis of opportunistically collected samples.
3. Equip DPI and DSE officers across southern and central Victoria with the knowledge and equipment to collect, label, temporarily store and dispatch swab samples from carcasses that appear to have been killed by a 'big cat'.
4. Enlist the aid of suitably qualified veterinarians to undertake forensic examination of prey carcasses.
5. Develop a contingency plan to be activated should cats belonging to a species other than the Domestic Cat be detected.

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Appendix 1. Summary of identifying characteristics of predatory mammals that could conceivably be the basis of claims of 'big cats' in Victoria

Species	Size	Coat	Ears	Tail length to body ratio	Kill characteristics	Tracks
Domestic Cat *Felis catus*	Weight 3-16 kg Shoulder height ~ 35 cm Total length 72-83 cm Tail length 26-30 cm [1]	Short to long, colour variable[1]	Pointed, high on head, closer together than in larger cats [2]	0.3-0.6. Short tail relative to body. Fur soft, may be long. [1]	Diet consist mostly of small mammals, birds and reptiles but does scavenge [3]	Inside toe leads outside toe. Central pad lobed at base. Claw marks not usually visible. Toe pads tear drop shaped. 'Squared off' leading edge of heel pad. Length 35 mm, Width 40 mm [4,5,6]
Leopard *Panthera pardus* (melanistic morph)	Weight30-80 kg Shoulder height 45-80 cm Total Length 160-280 cm Head body 100-190 cm[7] Tail Length 68-110 cm [7,8,9]	Short and sleek. Spots still visible in certain light [9]	Rounded, low on head and spaced widely apart. [2]	0.6 to 1. Longer tail relative to body. Distal end often curled. [9] Fur short, coarse.	Bite wounds to throat and back of neck and head. Claw puncture wounds to shoulders, flank or back. Carcases sometimes cached in trees or covered with vegetation.	Inside toe leads outside toe. Central pad lobed at base. Claw marks not usually visible. Toe pads tear drop shaped. 'Squared off' leading edge of heel pad. Length >80 mm, Width >80 mm [7,9]
Jaguar *Panthera onca* (melanistic morph)	Weight 57-113 kg Shoulder height 68-76 cm Total length 157-260 cm Head body 112-185 cm Tail length 45-75 cm[10]	Short and sleek. Sports still visible in certain light. [10]	Rounded, low on head and spaced widely apart.[2]	0.3-0.5. Shorter tail relative to body. Upturned at tip.[10] Fur short, coarse.	Bite wounds to throat and back of neck and head. Claw puncture wounds to shoulders, flank or back.	Inside toe leads outside toe. Central pad lobed at base. Claw marks not usually visible. Toe pads tear drop shaped. 'Squared off' leading edge of heel pad. Length >80 mm, Width >80 mm[9]. Track width>length. Front track>hind. [6]
Puma (Mountain Lion, Cougar) *Felis concolor*	Weight 36-103 kg Shoulder height 60-76 cm Total length 172-274 cm Head body 105-196 cm Tail length 67-78 cm [8,11,12]	Uniform tawny-brown to grey. Dark tip to tail and dark face markings. [11]	Rounded, low on head and spaced widely apart. [2,11]	0.5-0.7 Longer tail relative to body length.[11]	Bite marks to throat, head or back of neck. Claw puncture wounds to shoulders, flanks or back. 'Neat' edges to openings, blood lapped up. Dragging and/or covering of carcase. Canine holes 45-50mm apart for upper jaw, 30-40mm apart for lower jaw. Carcases may be cached in trees. [13,14,15,16]	Inside toe leads outside toe. Central pad lobed at base. Claw marks not usually visible. Toe pads tear drop shaped. 'Squared off' leading edge of heel pad. Length >80 mm, Width >80 mm [7,9]. Track width≤length [6,11,13]
Wild Dog and Dingo *Canis lupus*	Weight 12-60 kg Shoulder Height 50-100 cm Head body 100-150 cm Tail Length 31-51 cm [17]	Variable	More pointed than big cats but less so than *Felis catus*	0.3-0.5 Shorter tail relative to body length.[17]	Damage to hind legs. Signs of struggle and blood trails on ground, including fur. Will attack neck and head of prey when attempting to kill. May be other injured animals in the flock/herd. [14,15,16,17,18]	Front toes level with each other. Claw marks usually visible. Oval shaped toe pads. Curved leading edge of heel pad. Length 80-100 mm, Width: 80-100 mm [4,5,6]
European Red Fox *Vulpes vulpes*	Weight 4.5-8.3 kg Head body 57–74 cm Tail Length 36-45 cm [17]	Rusty red-brown to brown	Pointed, appear large for head size	Long and bushy	Bite wounds to face and neck. Muzzle mutilated or may be eaten entirely. Consumption focused on viscera, entered from behind ribs or focused on nose, tongue and head. Canine teeth 25-32 mm apart [20,21]	Oval shaped toe pads. Claw marks sometimes present. Curved leading edge of heel pad. Length 50 mm, Width 50 mm [4]
Feral Pig *Sus scrofa*	Weight ~ 100 kg[19]	Grey-brown to black, patchy. Short, coarse hair. [19]	Large, pointed	Very short relative to body	Entire carcase except bones and feet likely to be consumed.[20,21]	Two toes. Unlikely to be confused with others. [4]

[1] Denny and Dickman 2010
[2] Arthur Blackham, Melbourne Zoo, *pers. com.*
[3] Jones and Coman 1981
[4] Triggs 1996
[5] http://www.bear-tracker.com/
[6] Murie 1954
[7] C and T Stuart 1997
[8] Schutze 2002
[9] Stander 2009
[10] Rabinowitz et. al. 2009
[11] Johnson *et. al.* 2009
[12] Palmer 1954
[13] Shaw *et. al.* 2007
[14] McKay 2005
[15] Texas Natural Resources Server 2012
[16] Internet Center for Wildlife Damage Management 2012
[17] Fleming *et. al.* 2001
[18] Thomson 2000
[19] Choquenot et. al. 1996
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